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Changes in the Abundance and Distribution of the American Oyster Population of the Dunk River Public Fishing Area of Bedeque Bay, Prince Edward Island.

T.W. Sephton and C.F. Bryan

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ABSTRACT

A quantitative assessment of the distribution, abundance and population structure of oysters (Crassostrea virginica) in the Dunk River Public Oyster Fishing Area of Bedeque Bay, P.E.I. (latitude 46° 22′ N) was conducted in July, 1987. A standardization of the transect sampling protocol with previous studies permitted a comparison of data reported for 1972 and 1977. The distribution of the total oyster population indicated that the total area of the bed has increased (27%) from 1972 to 1987 and shifted slightly from east to west. The oysters were contagiously distributed which accounts for the large variability in the data. There were changes in the distribution of high (>100 indiv m^{-2}), medium (10-100 m^{-2}) and low (<10 m^{-2}) density beds of the total population from 1972 to 1987. The distribution of the juvenile (length <35 mm), recruit (35-75 mm) and market size (>75 mm) oysters in 1987 is also presented. In 1987, the average density of total and market size oysters for the entire bed was 21.6 and 5.3 no. m^{-2}, respectively. This was significantly lower than that observed in 1977 (89.3 and 8.8 no. m^{-2}, respectively) and 1972 (69.2 and 11.7 no. m^{-2}, respectively). The 1987 size frequency data showed that the population structure for each of the identified beds was similar and that recruitment remains intermittent in nature.

RESUME

Une évaluation quantitative de la distribution, de l'abondance et de la structure de la population d'huîtres (Crassostrea virginica) du Banc Public de la rivière Dunk dans la Baie de Bedeque, I.P.E. (latitude 46° 22′ N), a été réalisé en juillet 1987. Une standardisation de la méthode d'échantillonage par transects avec les autres études permettaient une comparaison avec les donnés des années 1972 et 1977. La distribution de la population totale d'huîtres indiquait que la surface totale du banc augmentait (27%) de 1972 à 1987 et se déplaçait de l'est à l'ouest. Les huîtres ont été trouvées en agrégats ce qui expliquait la grande variabilité des données. Il y avait des changements dans la distribution des bancs presentant des densités haute (>100 indiv m^{-2}), moyenne (10-100 m^{-2}) et basse (<10 m^{-2}) de 1972 à 1987. La distribution des huîtres juvéniles (taille <35 mm), recrue (35-75 mm) et de taille commercial (>75 mm) sont présentées. En 1987, la densité moyenne du nombre total et de la taille commercial pour le banc était 21.6 et 5.3 no. m^{-2}, respectivement. Elle était significativement inférieures aux données observées en 1977 (89.3 et 8.8 no. m^{-2}, respectivement) et 1972 (69.2 et 11.7 no. m^{-2}, respectivement). Les données des fréquence taille de 1987 indiquaient que la structure de la population pour chacun des bancs identifiés étaient semblables et que le recrutement était intermittent en nature.

INTRODUCTION

The American oyster (Crassostrea virginica) population of the Dunk River Public Fishing Area in Bedeque Bay, (latitude 46° 22′ N) is one of the most productive in Prince Edward Island and remains one of the most important sources of legal size (minimum anterior-posterior length >75 mm) oysters for the spring relay fishery (Lavoie and Bryan 1980, 1981a). In the spring, licensed fishermen tong legal oysters, which are marginally bacterially contaminated, and relay them to leases for cleansing prior to the autumn lease hold and market fishery (Hawkins and Rowell 1985a). The spring fishery is generally regarded as beneficial to the natural recruitment process of the bed as tong fishing from May 1 to July 15 exposes clean cultch for spat to set on around mid July (Lavoie and Bryan 1981b). Accurate landing statistics are not available for the Bedeque Bay Public Fishing Areas (Dunk River and the smaller Wilmot River) but the total landings of oysters for Prince Edward Island from 1982 to 1987 averaged 1350 t per year for an average landed value of $1.8 million annually. An indication of the productivity of the public ground is available Rowell (1975) who estimated that a minimum of 50% of the provincial landings originate from Bedeque Bay and from the Dunk River Public Fishing Area in particular. Local DFO Area Office staff confirm that this estimate remains valid today.

The Dunk River Public Fishing Area was the subject of extensive stock assessment surveys from 1969 to 1977 and the results used to design and implement enhancement projects to increase the total area of the oyster-producing grounds (Hawkins and Rowell 1985a). It was envisaged that relaying oysters from overcrowded areas of the natural bed to suitable unpopulated grounds would create new oyster grounds (Lavoie and Bryan 1981b). Lavoie and Bryan (1981b) reported that although the new grounds proved suitable for grow-out purposes, they were not self sustaining due to lack of natural recruitment of oyster spat. The thinning of the original overcrowded beds resulted in only marginal improvements in oyster quality (Lavoie and Bryan 1981a). They also recommended that stock thinning projects of overcrowded soft bottom beds be avoided as they resulted in the elimination of natural cultch prior to next spatfall.

This report is an assessment of the distribution, abundance and structure of the oyster population of the Dunk River Public Fishing Area of Bedeque Bay, P.E.I., based on a quantitative study conducted in July, 1987. A standard sampling procedure, based on the previous studies conducted from 1969 to 1977 by Rowell and others as reported by Hawkins and Rowell (1985a), will permit an examination of the changes that have occurred in the population since it was last surveyed in 1977. The data reported for 1972 (Hawkins and Rowell 1985b) and 1977 (Hawkins and Rowell 1985c) are re-analyzed with additional information available to us (Lavoie and Bryan, unpublished field survey notes and data used to map the original survey data) and re-presented for comparative purposes. This present study was designed to obtain baseline field data required to initiate further studies on the biology and ecology of the Bedeque Bay oyster population.

MATERIAL AND METHODS

The Dunk River Public Fishing Area of Bedeque Bay (Fig. 1) was sampled from 20-31 July 1987 using the transect method described by Hawkins and Rowell (1985a) and is briefly outlined here.

Shore to shore transects were drawn on a hydrographic chart at approximately 200 m intervals and located in the field using sextant and land marks. Random samples were collected at approximately 150 m intervals along the transect and averaged 15 samples per transect. Sample position was recorded in the field using a sextant and three arm protractor. A single 1 m^2 quadrat sample was collected at each station by divers handpicking all material within the quadrat. A 0.25 m^2 or 0.5 m^2 sample was collected in high density areas to avoid handling excessive quantities of material.

Samples were individually sorted from debris in the laboratory. All live oysters (>5 mm) were enumerated and maximum anterior - posterior length measured to the nearest 0.1 cm using calipers.

The data were used to map the distribution of the total population, the juvenile (length <35 mm) and legal size (length >75 mm) oysters to delineate the low (<10 oysters m^{-2}), medium (10-100 oysters m^{-2}) and high (>100 oysters m^{-2}) density areas using the bed designations as described by Lavoie (1977). The hand drawn maps were digitized and a computer aided drafting package used to produce the final maps.

The survey data (density estimates, size frequency distributions and sample site locations) for 1972 (Hawkins and Rowell 1985b) and 1977 (Hawkins and Rowell 1985c) was re-analyzed using field observation notes (Lavoie and Bryan, unpublished data). Distribution maps were created for the total oyster population for 1972 and 1977 and redrawn to scale for comparison with 1987. The bed location information was used to partition the station density data to calculate the average density of total number and legal size oysters for each of the beds.

The 1972 survey sampled an area between Oyster Point and Hurd Point in the west, to Murray Island in the east and was composed of 13 transects with a total of 148 stations (Hawkins and Rowell 1985b)(see Fig. 2 for reference). The 1977 survey covered slightly less area than that of 1972, extending from midway between Oyster and Hurd Points to Lower Bedeque in the west, to just south of Murray Island in the east. 16 transects were used and 186 samples obtained in the survey (Hawkins and Rowell 1985c). The 1987 suvey covered the same area as the 1972 survey and was composed of 18 transects with a total of 200 samples.

The average density estimates for each of the beds and the total bed (excluding the channel) for 1972, 1977 and 1987 was used in the calculation of analysis of variance and orthogonal contrasts (SAS GLM) (SAS Institute 1985) to identify significant ($p<0.05$) changes in the average numerical abundance of oysters between 1972, 1977 and 1987 surveys. The square root ($x + 0.05$) transformation was used to stabilize the variances.

The von Bertalanffy growth curve of Lavoie and Bryan (1981b) was used to derive the age (year) classes from the length data and is:

$$L(cm) = 15.3\ (1-e^{-0.186[t-0.16]}).$$

RESULTS

SPATIAL DISTRIBUTION

The distribution map for the total oyster population, delineating the low, medium and high density areas (beds) for 1987 is shown in Figure 2. The total area (excluding the channel) was estimated to be 142 ha in 1987 (Table 1). The large medium density beds located near Oyster Point and on the opposite side of the channel are surrounded by larger low density beds. Three small medium density beds on the south side of the Dunk River near lower Bedeque are separated by the low density bed which bends around towards Hurd Point. The medium density beds have a total area of 58 ha while the low density bed area was 77.5 ha. The high density bed is small (6.4 ha) and narrow and parallels the north side of the channel bed. The channel bed is distinct, delineated by the channel boundaries, and typical of other channel habitat in that there are high concentrations of oysters which are unsuitable for market sale because of their twisted and poor nonuniform shape. However, these channel oysters may be harvested as brood stock and relayed to private leases.

The distribution of market size oysters is shown in Figure 3. There are low concentrations of these legal size (length >75 mm) oysters over much of the bed with a medium concentration on either side of the channel bed. The distribution of juvenile (length <35 mm) oysters is shown in Figure 4 and the location of medium and low density bed corresponds well with the total distribution map. This indicates that the main area of high survival, and possibly spatfall, appears to be that area in the middle of the bed on either side of the channel and the channel itself. Large concentrations of juveniles are found in the channel where they grow on the shells of adult oysters and on empty shells.

Oyster distribution and densities beds in 1972 and 1977 are shown in Figures 5 and 6, respectively. High density beds, surrounded by medium density ones, were observed in both years and in similar locations. Some changes were observed from 1972 to 1977: the small high density bed near Lower Bedeque became a medium density area in 1977; the medium density one along the north side of the channel was observed as a high density one in 1977; and the low and medium density areas became less distinct through time. The total area covered by the Public Fishing Area was the same (104 ha) in both years (Table 1) as were the channel and high density bed areas. The medium density area decreased (22%) from 1972 to 1977 while the low density bed increased (21%) in total area (Table 1).

A comparison of the 1987 oyster distribution with the other maps show some distinct changes have occurred since 1977. The high density areas have declined to medium density areas with the exception of the ribbon bed running parallel to the channel along the north side. The low density beds adjacent to Oyster Point and Lower Bedeque have now increased in size and extended themselves westward. Also, the east side of the bed, nearest Murray Island, has almost completely disappeared with the exception of relic clump of oysters in the channel. These changes make it appear as if the entire bed has shifted from east to west and into the more open and deeper areas of the estuary. The entire area of the bed has increased in size from 1977 by almost 40%, this almost entirely attributable to the increased size of the low density bed.

AVERAGE DENSITY

The average density of oysters (no. m^{-2}), as partitioned into the bed and size (legal: length >75 mm, recruit: 35-75 mm, juvenile : <35 mm) categories and for the entire bed, is shown in Table 2. The overall total density, excluding the channel bed, was 21.6 m^{-2}, while the average density of the high, medium and low beds were 118.8, 34.2 and 2.3 m^{-2} respectively. The density of the channel bed was lower (60.2 m^{-2}) than that of the high density bed. Juveniles composed 27% of the total density while recruits contributed 48%, and this representation was similar for each of the individual beds.

Table 3 shows the densities estimated for the total and legal size oysters for each of the different density beds and the total bed for the Public Fishing Area for 1972, 1977 and 1987. A summary of the results of analysis of variance and orthogonal contrasts is presented in Table 4. In general, the total densities for most beds and the entire bed increased from 1972 to 1977 and decreased in 1987 to levels at or below those observed in 1972. The only statistically significant change in total density was the decrease observed for the entire bed from 1977 to 1987 (Table 4). The density of legal size oysters varied between years over the entire bed and for the different density beds. Even though the total density of legal size oysters decreased from 1972 to 1987 by half, there was sufficient variability (many samples with densities less than 5) in the data such that the analysis of variance was not significant.

Overall, the available legal size biomass decreased from 1045 t in 1972 to 651 t in 1987 (Table 3). This corresponds to an approximate decrease of 10,000 boxes of oysters over the same time period.

SIZE FREQUENCY DISTRIBUTION

The size frequency distributions of oysters collected from the high, medium and low density beds and the channel bed are shown together in Figure 7 and for the entire bed in Figure 8 and 9. The size distributions for the medium and high density bed, and the total overall bed are similar. They are all bimodal with a peak occurring at size intervals 10 to 20 mm and a second broader peak between the 45 to 80 mm size intervals. The single spike in the largest size category reflects the pooling of all oysters greater than 115mm in shell length. There is a rapid decline in the size frequency distributions of all three histograms after the legal (market) size of 75 mm. The proportion of juvenile oysters is small in comparison with the others and this indicates that natural recruitment to the overall population was low from 1985 to 1987.

The size frequency distributions for the low density and channel beds is not consistent with others and this may be due to the low sample size. There are multiple peaks in both but one distinct feature appears as a broad peak from 10 to 25 mm intervals. The general shape of the distributions are similar to those described above and may have resembled them better had the sample size been larger. There appears to be little effect of fishing (decline of oysters larger than 75mm) on the distributions although the cummulative effects of the patchy distribution and a spring fishery may have contributed to these observations.

The growth curve from Lavoie and Bryan (1981b) has been used to show the year class intervals on the total frequency distribution in Figure 8. A good level of recruitment in 1983 and 1984 appears to be sustaining the fishery at this time.

Comparison of the size frequency distributions for the total oyster population of the Public Fishing Area for 1972, 1977 and 1987 show clearly that the levels of juvenile recruitment observed in 1977 and 1972 have not been observed recently (Fig. 8). In 1972 and 1977, the distributions are unimodal, with a peak in the distribution from 15 to 30 mm, and followed by a broad skewed tail towards the larger size classes. An examination of the size frequency distributions for other published data (Hawkins and Rowell 1984a, Lavoie and Bryan 1981b) (Fig. 9) indicates that recruitment pulses are intermittent in nature. Good levels are clearly identifiable in the size frequency distributions for 1970, 1977 and 1980. Information from local fishermen indicate that a large spatfall occurred in 1988.

DISCUSSION

Although the physical size of the Dunk River Public Fishing Area did not change from 1972 to 1977 (Table 1), the location and size of different density beds changed noticeably (Figs. 5,6). The centrally located high density area decreased in size while the small Oyster Point bed increased and spread along the north side of the channel during this time period. Also, the medium density bed near Murray Island developed a high density patch from 1972 to 1977. Examination of the data (Hawkins and Rowell 1985c) suggest that this latter bed could have been the result of a fortuitous spatfall and survival as it had a high proportion of juvenile oysters. In 1987, even though the beds near Murray Island had disappeared (Fig. 2), the total area of the Public Fishing Area had increased by almost 40%. This was due primarily to the expansion of the western side of the low density beds towards Hurd Point. This apparent change in location and expansion of the entire Public Fishing Area from east to west cannot be considered an artifact of the transect sampling method. Diver observations from 1987 indicate that the substrate of the former high and medium density beds near Murray Island was inconsistent: with areas of soft and firm mud and hard sand, and barren of suitable oyster cultch (clean empty shell) that had been observed in earlier surveys (1969 survey reported by Hawkins and Rowell 1985a). This deterioration of once suitable oyster ground may be the result of the combined effects of silt and winter ice scour which would eliminate the once available cultch (Medcof 1961, Galtsoff 1964). There is no evidence that overfishing contributed to the problem as tonging would have continually exposed cultch for new spat to settle on. In 1987, very little shell material was observed.

The centrally located high density beds of 1972 and 1977 became a medium density area by 1987 (Figs. 5,6,2). Concurrent with this was the change in size of Oyster Point high density bed from 1972 to 1987 and the gradual establishment and expansion of the parallel bed along the north side of the channel. The channel bed itself decreased in size from 1972 to 1987 but maintained it's approximate position. Although it is widely

accepted that the channel substrate conditions are not conducive to growing oysters of market quality (Galtsoff 1964, Lavoie 1977), these clumps of oysters and those found in high density areas do provide cultch for spat to settle on. The large percentage of juvenile oysters found in these two areas in 1987 (Fig. 7) suggest that it may be a zone of natural recruitment: an area of larval retention and spatfall (Haven et al. 1987). This circumstantial evidence suggests that these areas of natural recruitment have changed over time but it remains to be seen if the westward expansion of the low density beds are self sustaining or the result of fortuitous spatfalls.

The increase in the area of the medium and low density beds is considered beneficial by increasing the overall market quality of oysters (Lavoie and Bryan 1981a). Lavoie and Bryan (1981a) reported that the reduced densities decreases the likelihood of physical contact, which occurs in overcrowded conditions, and thus increases the shell quality as oysters can grow undisturbed. This would normally result in increased dollar value for market sales in the half shell but statistics are not available to show this effect.

The average density of oysters for the entire bed was not statistically different from 1972 (69.2 m^{-2}) to 1977 (89.3 m^{-2}) but decreased significantly from 1977 to 1987 (21.6 m^{-2}). Statistical differences were not detected for the different density beds (Table 3) but the high density and channel beds decreased by 50% and 75% respectively. The data are quite variable (extreme range and skewed distribution of sample densities) and typical of the contagious distributions exhibited by oysters (Galtsoff 1964). The average density of legal size oysters changed between years but the changes were not statistically different (Table 3,4). Expressed in another way, the available biomass of legal size oysters decreased between years, from 25,613 boxes or 1,045 t in 1972 to 15, 947 boxes or 651 t in 1987. These data may be viewed as the residual legal biomass that remains after the spring relay fishery because all surveys were conducted after the spring fishery was completed. This biomass, combined with that to be recruited (the next year class) into the legal size range due to growth from the 60-75 mm size range, would be available for the next fishing season. Unfortunately, there is no official way to estimate the quantity of oysters relayed in the spring fishery to evaluate the accuracy of our estimated residual legal biomass from the surveys.

The area and the density of the channel beds decreased from 1977 to 1987 which is opposite of that observed for the Public Fishing Area of Caraquet Bay (Sephton and Bryan 1988). The channel beds are not usually fished by oystermen because of the poor shape, and thus quality, of the oysters found growing in the soft muds (Lavoie and Bryan 1981a). These "catpaws" provide cultch for spat and have long been considered by the local oystermen as a resident brood stock for the population. The observed changes support the first point but there is no local data available to support the second. Field notes and diver observations during the 1987 survey suggest that it may have been fished in the past, presumeably to relay brood stock as part of restocking programs.

The total size frequency distributions observed for the surveys being examined here (Fig. 8) and those of other surveys (Fig. 9) are typical of most bivalve mollusc populations (Loosanoff 1966, Powell and Cummins 1985). The high levels of juvenile recruitment, as implied by the size frequency distributions, observed for year classes 1971, 1976, 1980, and perhaps

1983 and 1984, have not been observed in recent times (1985 to 1987). This is evident from the increase in the percentage composition of legal size oysters in the frequency distribtions of late. Similar sporadic pulses of recruitment have also been observed in Caraquet Bay (Sephton and Bryan 1988). The present fishery in the Dunk River is being sustained by the 1983 and 1984 year classes, but the prognosis is not as good for the future based on the size of the 1985 and 1986 year classes. Reports from local oystermen suggest that although spatfall was a dismal failure in 1986 and 1987, an excellent spatfall was observed in 1988. This should be assessed formally for comparison with historical data to estimate the success of the recruitment and the eventual impact on the fishery. Also, an attempt should be made to estimate a new growth curve which reflects the present environmental growing conditions.

The Dunk River Public Fishing Area of Bedeque Bay remains a self sustaining bed with intermittent recruitment to the population. Although the size of the bed has increased in area from 1977, the average oyster density has decreased significantly from 1977. The oyster population appears to have stabilized at these lower densities but the fishable biomass may continue to decline over the next few years if recruitment stays at the low levels observed recently.

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LITERATURE CITED

Galtsoff, P.S. 1964. The American oyster Crassostrea virginica Gmelin. Fish. Bull. U.S. Fish. Wildl. Ser. 64:480 p.

Haven, D.S., J.M. Zeigler, J.T. Dealteris, and J.P. Whitcomb. 1987. Comparative attachment, growth and mortalities of oyster (Crassostrea virginica) spat on slate and oyster shell in the James River, Virginia. J. Shellfish Res. 6:45-48.

Hawkins, C.M. and T.W. Rowell. 1985a. Population survey of the oyster Crassostrea virginica in the Dunk River Estuary, Prince Edward Island, 1969 and 1970. Can. MS Rep. Fish. Aquat. Sci. 1857:iv + 107 p.

1985b. Population survey of the oyster Crassostrea virginica in the Dunk River Estuary, Prince Edward Island, 1972. Can. MS Rep. Fish. Aquat. Sci. 1858:iv + 45 p.

1985c. Population survey of the oyster Crassostrea virginica in the Dunk River Estuary, Prince Edward Island, 1977. Can. MS Rep. Fish. Aquat. Sci. 1863:iv + 108 p.

Lavoie, R.E. 1977. The oyster population of the Public Fishing Area, Caraquet Bay, New Brunswick. Fish. Mar. Serv. Tech. Rep. 735:39 p.

Lavoie, R.E. and C.F. Bryan. 1980. Impact of stock thinning and relocation on oyster quality and value - Dunk River, P.E.I. (Part 1 of 2). Can. MS Rep. Fish. Aquat. Sci. 1587:v + 15 p.

1981a. Medium-term value of stock thinning for oyster resource enhancement - Dunk River, P.E.I. (Part 2 of 2). Can. Tech. Rep. Fish. Aquat. Sci. 1010:v + 13 p.

1981b. Oyster bed development in the Dunk River, P.E.I., 1975-1980. Can. Tech. Rep. Fish. Aquat. Sci. 1015:iv + 14 p.

Loosanoff, V.L. 1966. Time and intensity of setting of the oyster, Crassostrea virginica, in Long Island Sound. Biol. Bull. (Woods Hole) 130:211-227.

Medcof, J.C. 1961. Oyster farming in the Maritimes. Fish. Res. Bd. Canada Bull. 131:158 p.

Powell, E.N. and H. Cummins. 1985. Are molluscan maximum life spans determined by long term cycles in benthic communities? Oecologia 67:177-183.

Rowell, T.W. 1975. Maritime oyster culture, development potentials and limitations. Proc. Bras d'Or Aquacultue Conf., College of Cape Breton Press, Sydney, N.S.:130-139.

SAS Institute Inc. 1985. SAS/STAT guide for personal computers. Cary, N.C. 1028p.

Sephton, T.W. and C.F. Bryan. 1988. Abundance, distribution and dynamics of the American oyster population of the Public Fishing Area of Caraquet Bay, New Brunswick. Can. Tech. Rep. Fish. Aquat. Sci. 1654:vi + 18p.

TABLE 1. Comparison of the physical area (ha) of the total bed and the different density beds of the Dunk River Public Fishing Area of Bedeque Bay for 1972, 1977 and 1987.

BED	AREA (ha) 1972	1977	1987
LOW	26.6	33.7	77.5
MEDIUM	51.8	42.4	57.9
HIGH	25.1	27.8	6.5
CHANNEL	11.2	11.3	8.9
TOTAL excluding channel	103.5	103.9	141.9

TABLE 2. Average density (no. m^{-2}) of oysters for each of the size categories for each of the beds identified and the total bed of the Dunk River Public Fishing Area of Bedeque Bay in 1987.

BED	NUMBER SAMPLE N	TOTAL $no.m^{-2}$ ± SE	LEGAL $no.m^{-2}$ ± SE	RECRUIT $no.m^{-2}$ ±SE	JUVENILE $no.m^{-2}$ ± SE
HIGH	5	118.8 ±23.8	30.1 ± 12.1	53.2 ± 16.7	35.6 ± 2.7
MEDIUM	43	34.2 ± 3.6	8.1 ±1.1	17.3 ± 2.1	8.9 ± 0.9
LOW	53	2.3 ± 0.4	0.9 ±0.1	0.8 ± 0.2	0.6 ± 0.2
CHANNEL	10	60.2 ± 36.9	27.5 ± 17.1	14.6 ± 8.6	18.1 ±11.6
TOTAL BED	111	25.2 ± 4.5	7.3 ± 1.8	10.8 ± 1.7	7.1 ± 1.3
TOTAL excluding channel	101	21.6 ± 3.3	5.3 ± 0.9	10.4 ± 1.7	5.9 ± 0.9

TABLE 3. Comparison of the total and legal size (length>75mm) average density (no.m^{-2}) for each of the different density beds and the total bed of the Dunk River Public Fishing Area of Bedeque Bay for 1972, 1977 and 1987. An estimate of the available legal size biomass as total metric tons and boxes is also presented.

	1972		1977		1987	
BED	TOTAL no.m^{-2} ± SE	LEGAL no.m^{-2} ± SE	TOTAL no.m^{-2} ± SE	LEGAL no.m^{-2} ± SE	TOTAL no.m^{-2} ± SE	LEGAL no.m^{-2} ± SE
HIGH	205.2 ±24.6	33.7 ±4.9	233.9 ± 27.8	21.1 ± 4.1	118.8 ±23.8	29.6 ± 12.2
MEDIUM	30.9 ± 3.4	5.6 ±0.8	42.8 ± 4.6	5.1 ± 0.7	34.2 ± 3.6	8.1 ± 1.1
LOW	3.2 ± 0.8	0.7 ±0.2	3.5 ± 0.9	1.1 ± 0.2	2.3 ±0.4	0.9 ± 0.1
CHANNEL	187.2 ±69.9	23.6 ±7.5	155.9 ± 80.9	14.9 ± 7.7	60.2 ±36.9	27.5 ± 16.9
TOTAL excluding channel	69.2 ±12.2	11.7 ±2.1	89.3 ± 12.6	8.8 ± 1.5	21.6 ± 3.3	5.3 ± 0.9
BOXES LEGAL SIZE OYSTERS *		25613 boxes		18720 boxes		15947 boxes
TONS LEGAL SIZE OYSTERS *		1045 t		764 t		651 t

* One metric ton contains 24.5 standard oyster boxes which contain 450-500 legal size (length>75mm) oysters per box (Lavoie 1977).

TABLE 4. Summary of the results of analysis of variance and orthogonal contrasts to determine if there were significant differences ($p<0.05$) in the density of total and legal size oysters between years over the different density beds and the entire bed of the Dunk River Public Fishing Area of Bedeque Bay.

COMPARISON	df	F	P	Orthogonal Contrasts
Total Oysters				
High Density Bed	2 47	2.65	NS	[1972 = 1977 ≠ 1987]
Medium Density Bed	2 118	1.55	NS	[1972 = 1977 = 1987]
Low Density Bed	2 89	0.95	NS	[1972 = 1977 = 1987]
Entire Bed	4 258	3.03	*	1972 = 1977 ≠ 1987
Legal Size Oysters				
High Density Bed	2 47	2.19	NS	[1972 ≠ 1977 = 1987]
Medium Density Bed	2 118	1.97	NS	[1972 = 1977 = 1987]
Low Density Bed	2 89	0.23	NS	[1972 = 1977 = 1987]
Entire Bed	4 258	2.92	NS	[1972 ≠ 1977 ≠ 1987]

NS not significant
* P<0.05

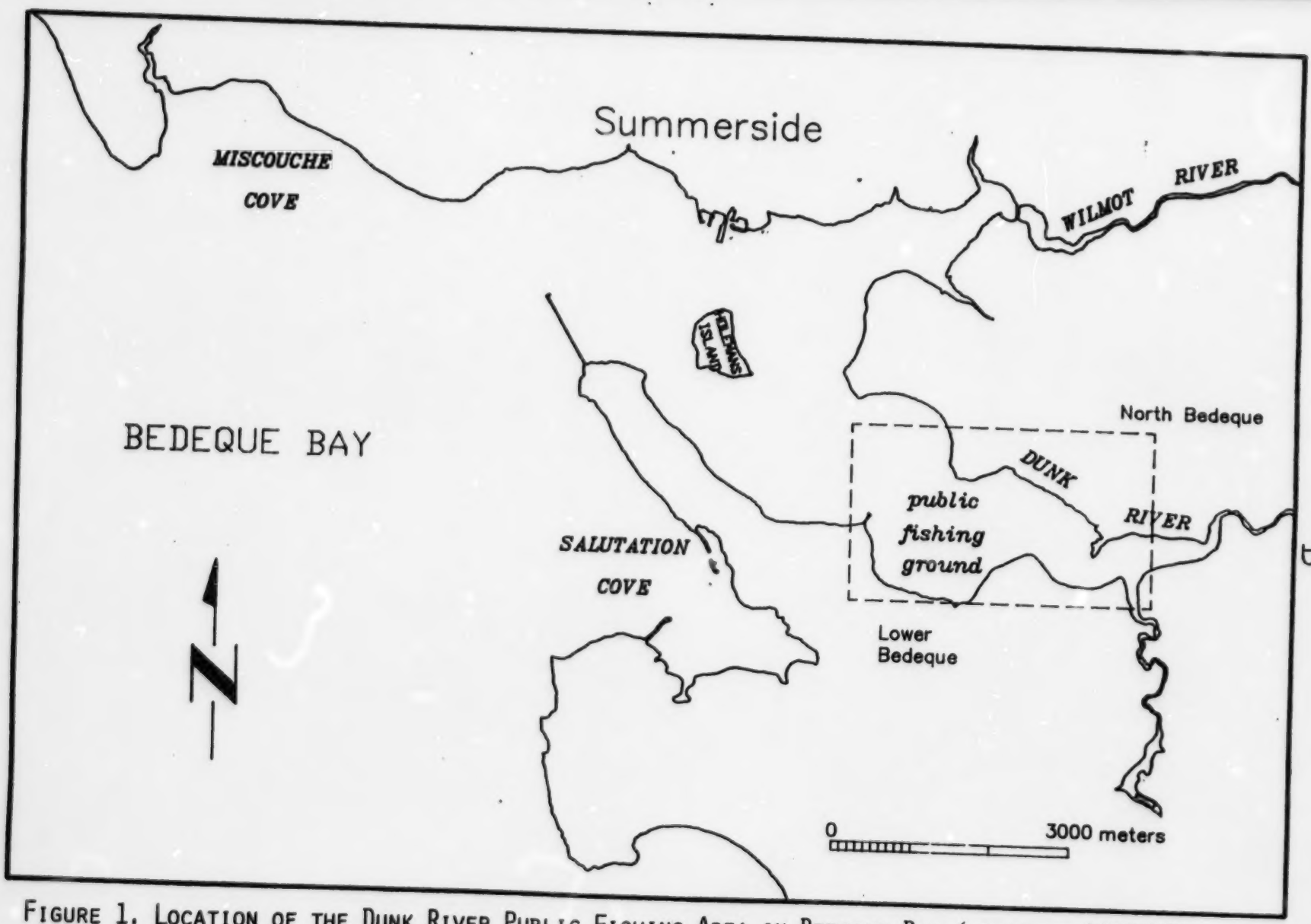

FIGURE 1. LOCATION OF THE DUNK RIVER PUBLIC FISHING AREA IN BEDEQUE BAY (LATITUDE 46° 22' N), PRINCE EDWARD ISLAND, CANADA.

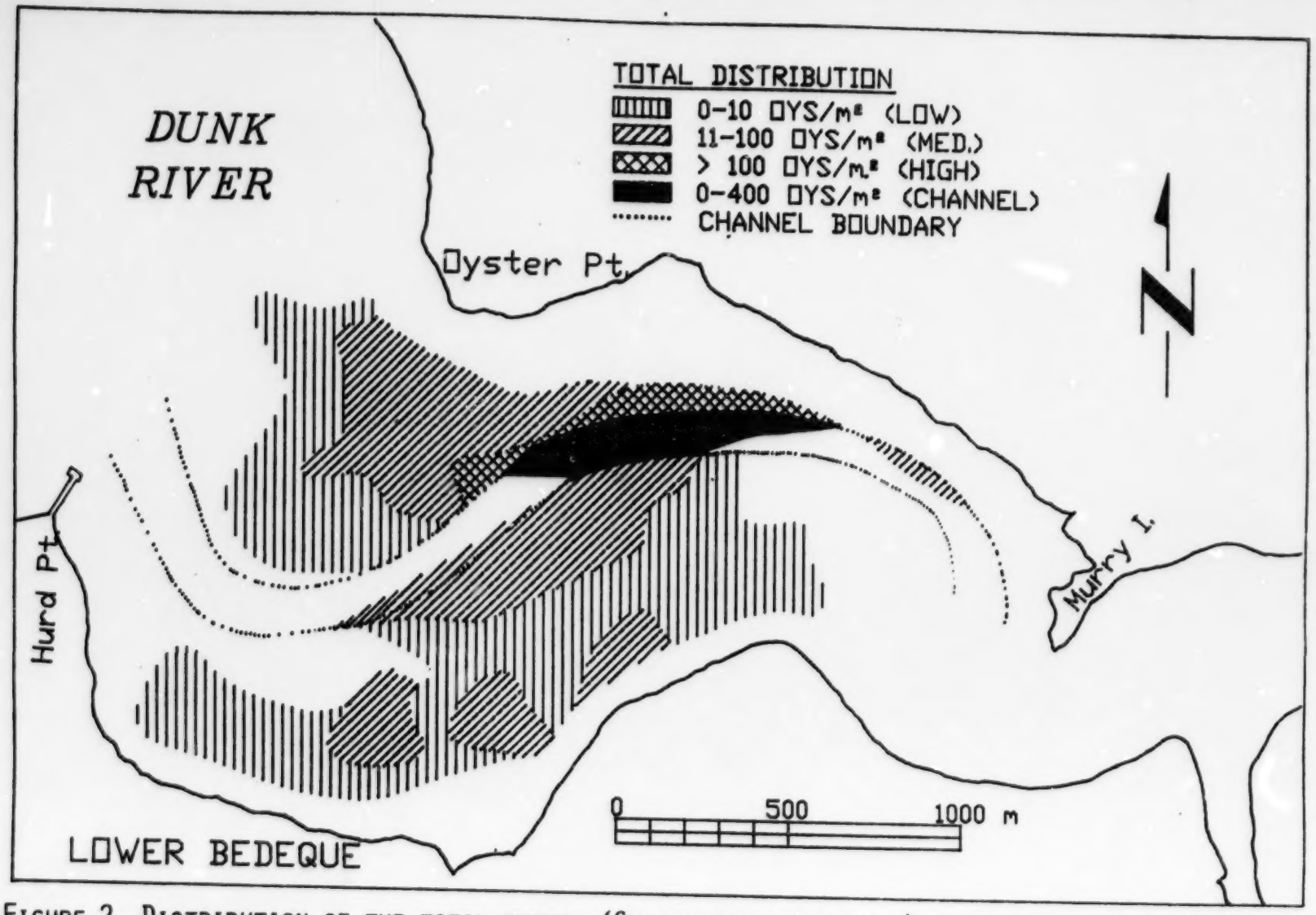

FIGURE 2. DISTRIBUTION OF THE TOTAL OYSTER (CRASSOSTREA VIRGINICA) POPULATION, SHOWING THE DIFFERENT DENSITY BEDS OF THE DUNK RIVER PUBLIC FISHING AREA OF BEDEQUE BAY IN 1987.

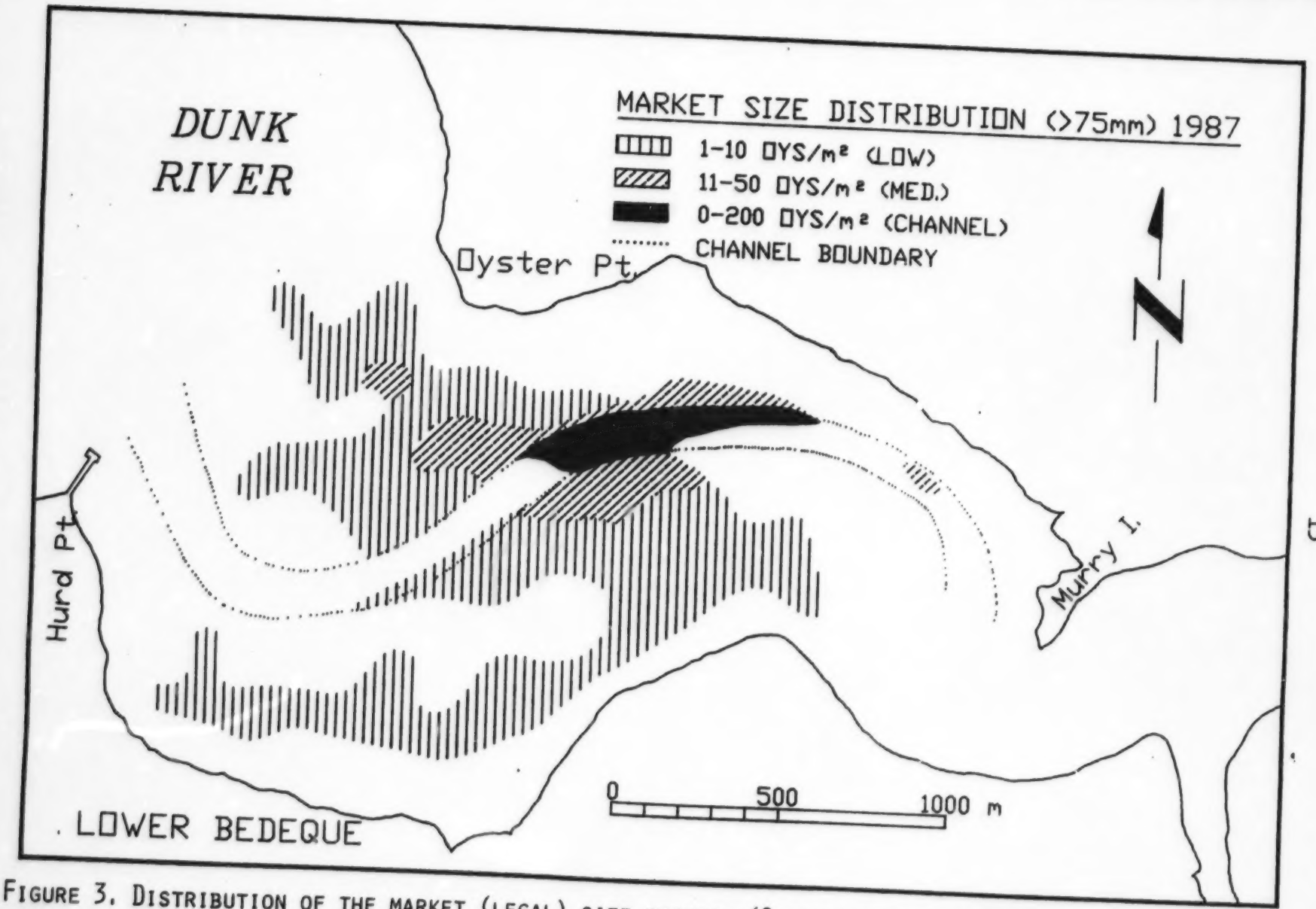

FIGURE 3. DISTRIBUTION OF THE MARKET (LEGAL) SIZE OYSTERS (CRASSOSTREA VIRGINICA) OF THE DUNK RIVER PUBLIC FISHING AREA OF BEDEQUE BAY IN 1987.

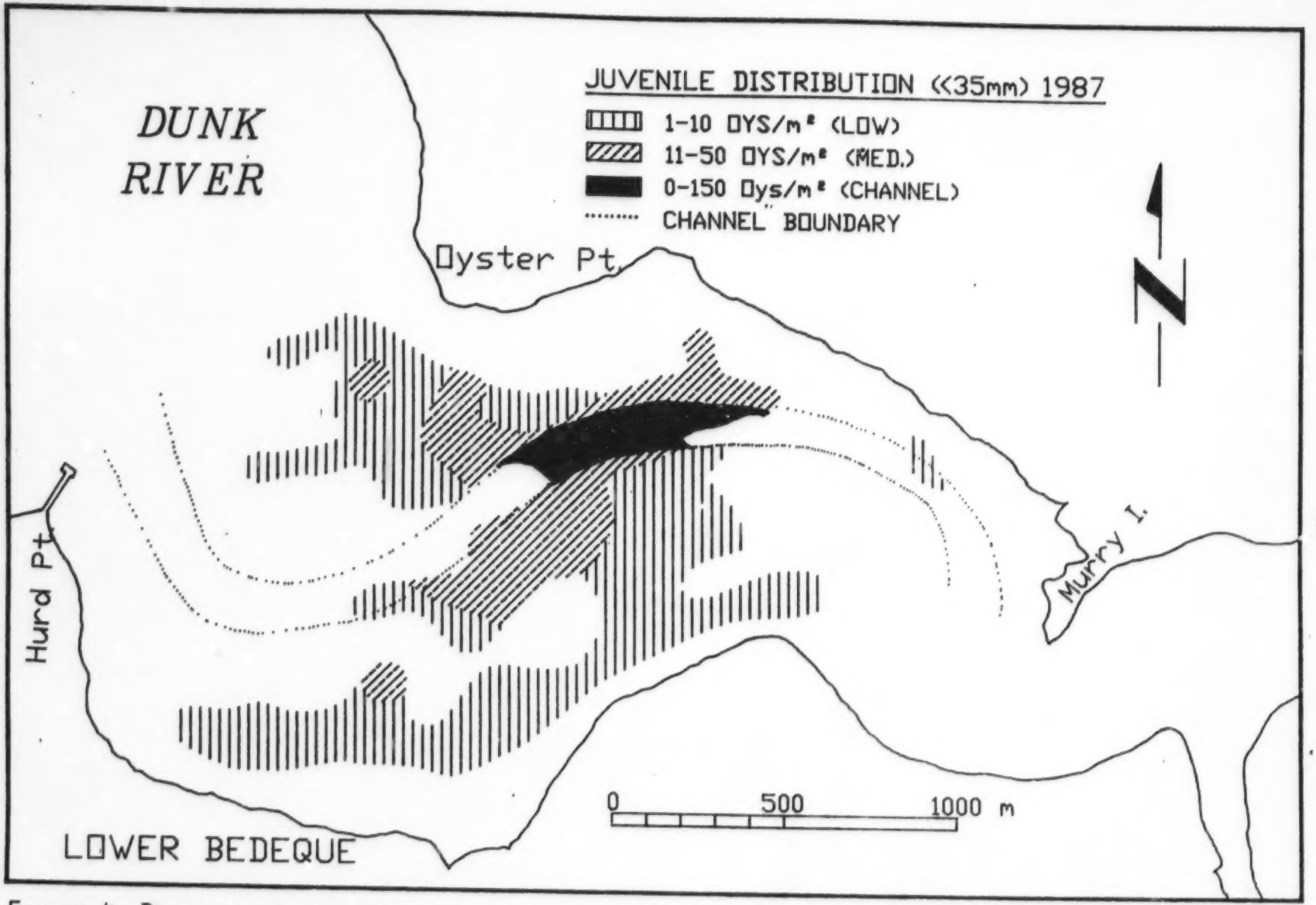

FIGURE 4. DISTRIBUTION OF THE JUVENILE SIZE OYSTERS (CRASSOSTREA VIRGINICA) OF THE DUNK RIVER PUBLIC FISHING AREA OF BEDEQUE BAY IN 1987.

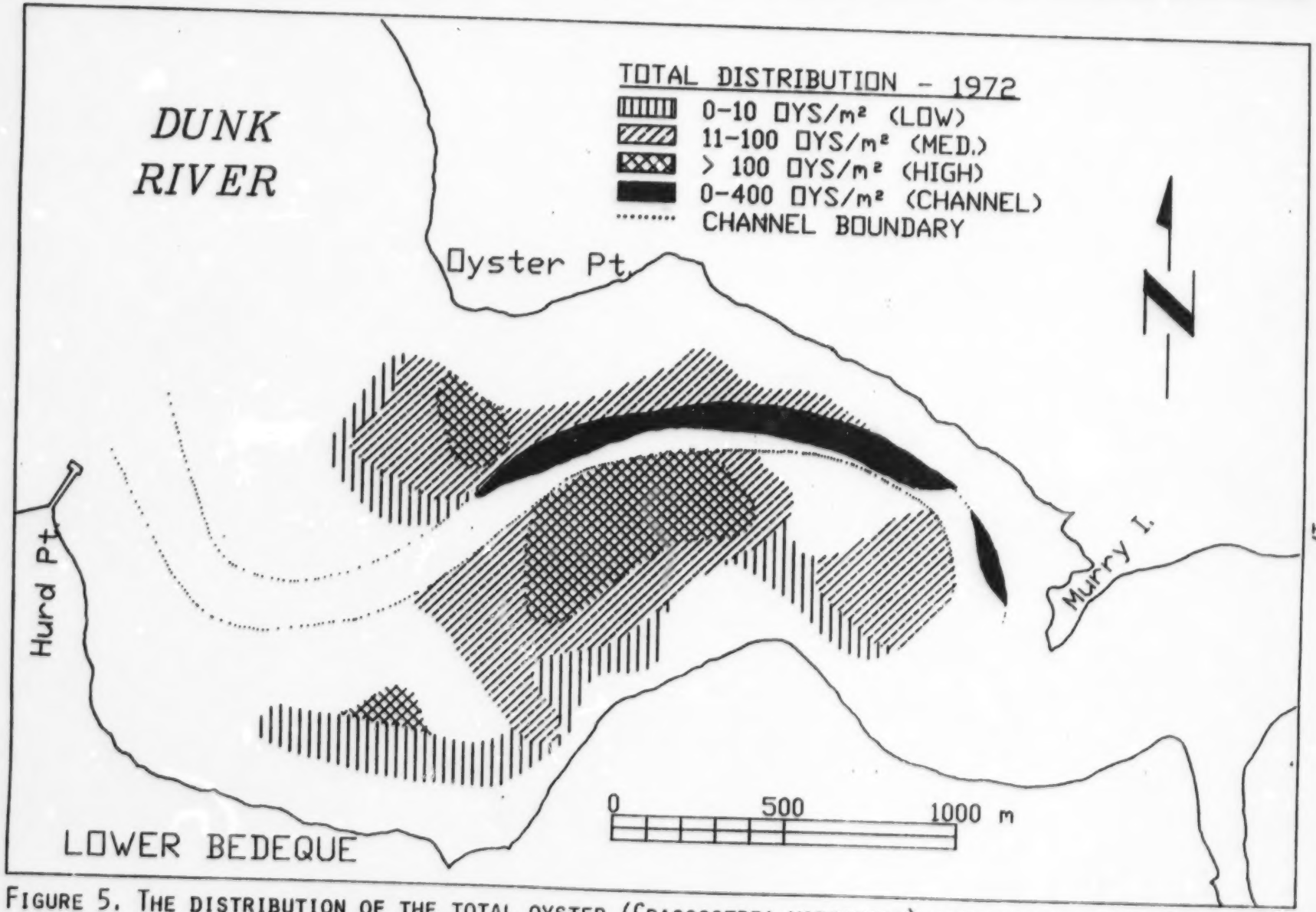

FIGURE 5. THE DISTRIBUTION OF THE TOTAL OYSTER (CRASSOSTREA VIRGINICA) POPULATION OF THE DUNK RIVER PUBLIC FISHING AREA OF BEDEQUE BAY IN 1972.

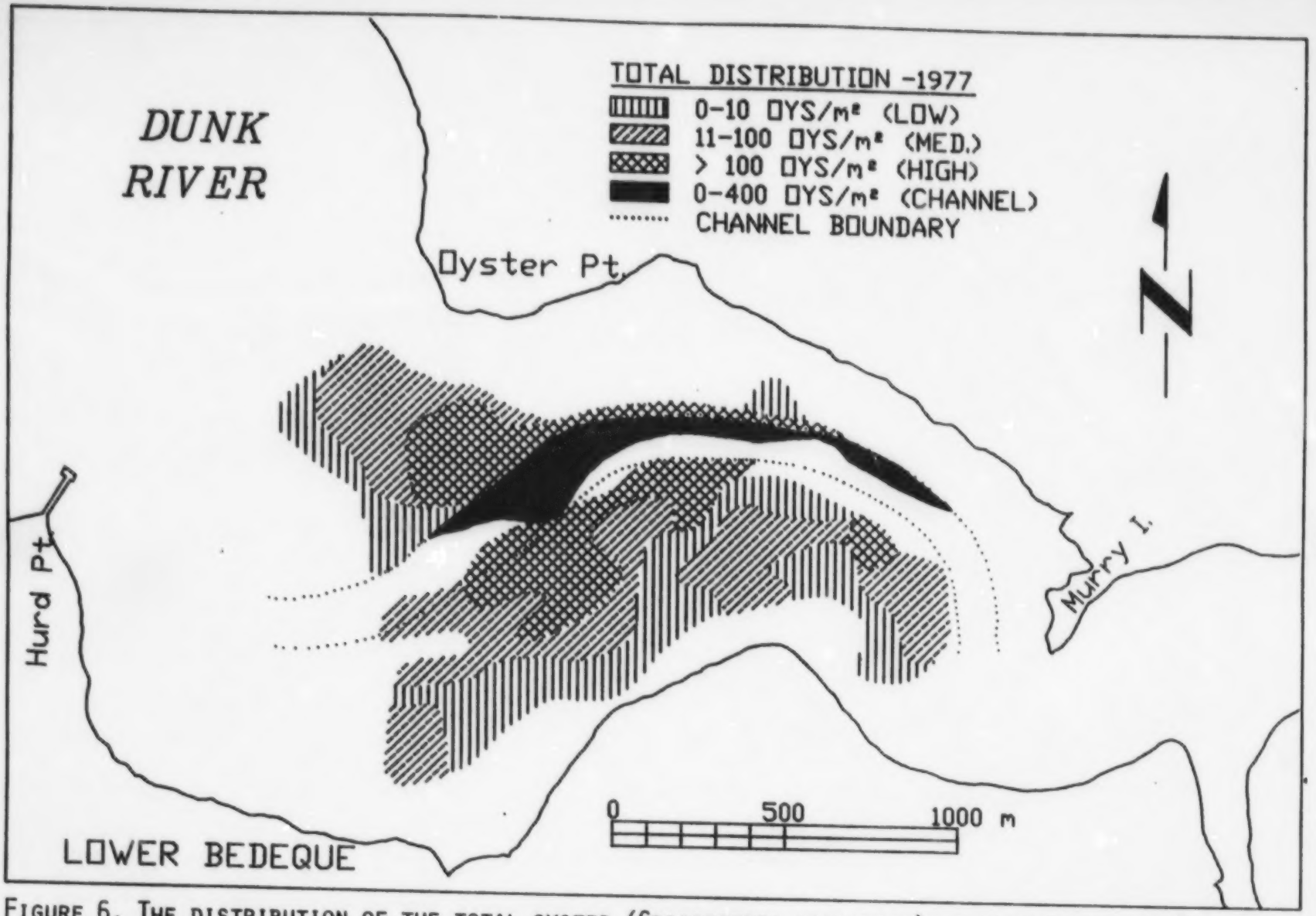

FIGURE 6. THE DISTRIBUTION OF THE TOTAL OYSTER (CRASSOSTREA VIRGINICA) POPULATION OF THE DUNK RIVER PUBLIC FISHING AREA OF BEDEQUE BAY IN 1977.

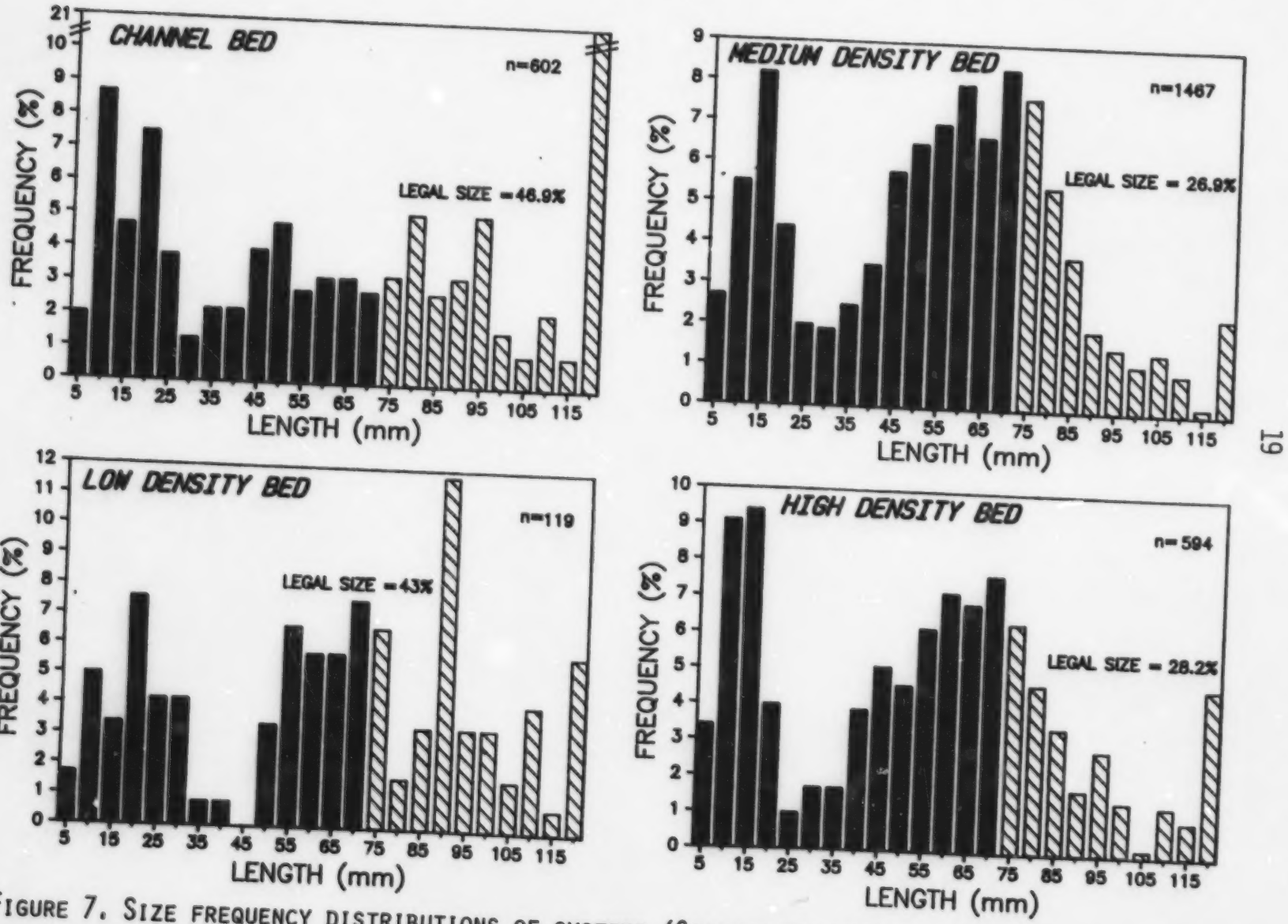

FIGURE 7. SIZE FREQUENCY DISTRIBUTIONS OF OYSTERS (CRASSOSTREA VIRGINICA) OF THE LOW, MEDIUM AND HIGH DENSITY BEDS AND THE CHANNEL BED OF THE DUNK RIVER PUBLIC FISHING AREA OF BEDEQUE BAY IN 1987.

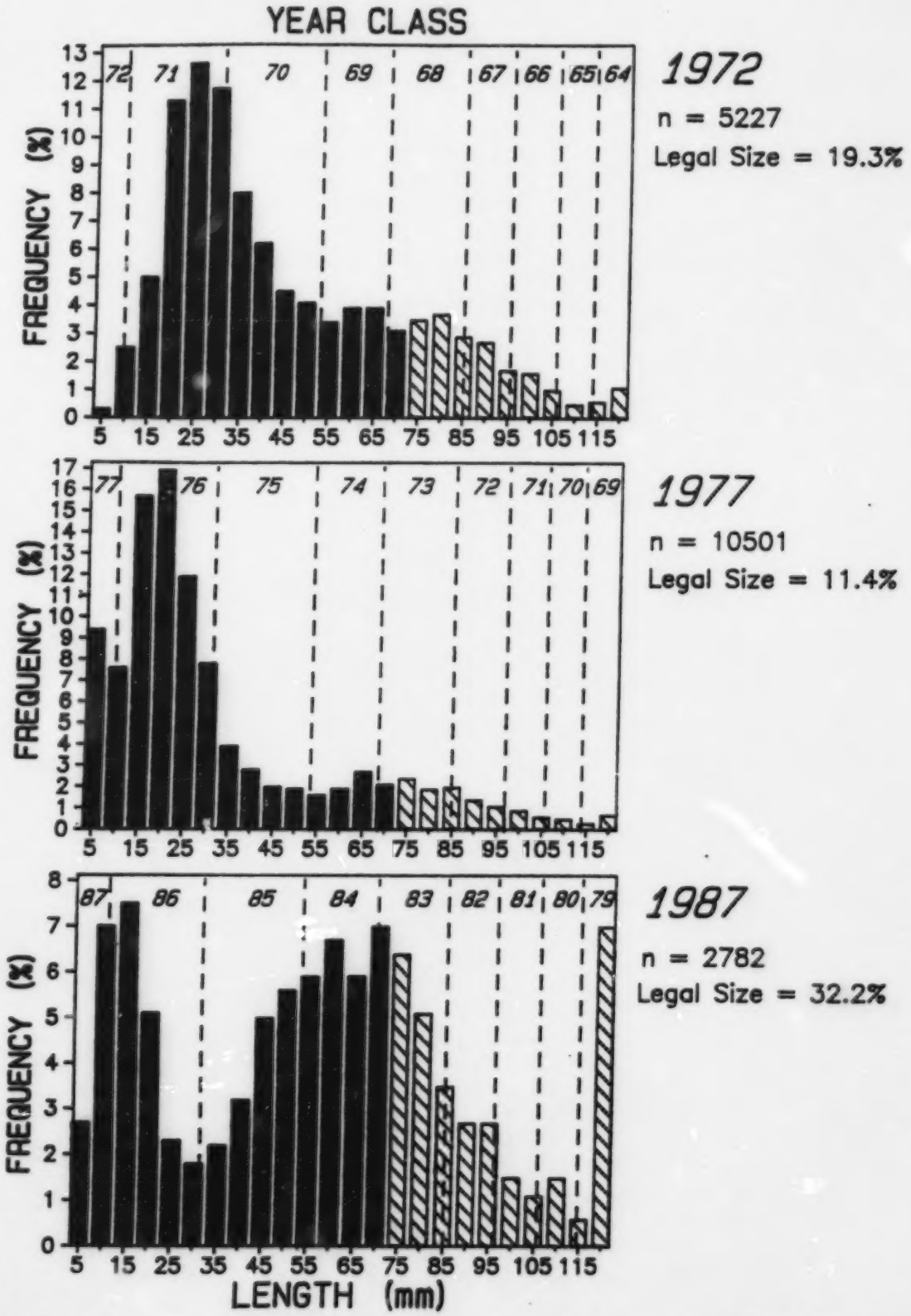

FIGURE 8. SIZE FREQUENCY DISTRIBUTIONS OF THE TOTAL OYSTER (CRASSOSTREA VIRGINICA) POPULATION OF THE DUNK RIVER PUBLIC FISHING AREA OF BEDEQUE BAY IN 1972, 1977 AND 1987. YEAR CLASS DESIGNATIONS ARE ALSO SHOWN.

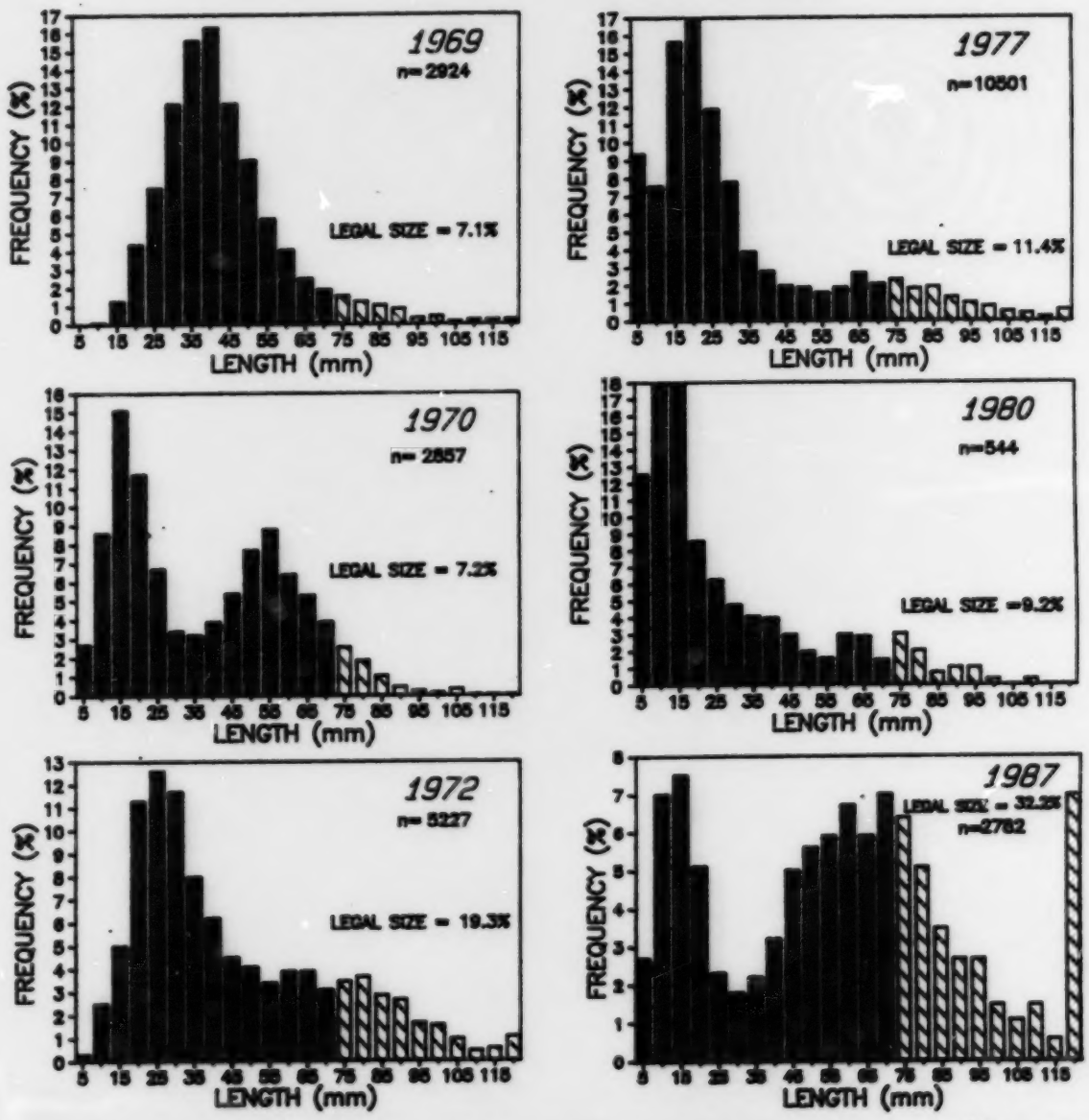

FIGURE 9. SIZE FREQUENCY DISTRIBUTIONS OF THE TOTAL OYSTER (CRASSOSTREA VIRGINICA) POPULATION OF THE DUNK RIVER PUBLIC FISHING AREA OF BEDEQUE BAY IN 1969 (HAWKINS & ROWELL 1985A), 1970 (HAWKINS & ROWELL 1985A), 1972 (HAWKINS & ROWELL 1985B), 1977 (HAWKINS & ROWELL 1985C), 1980 (LAVOIE & BRYAN 1981B) AND 1987.